



Optical characteristics of CDOM in meromictic water bodies (White Sea) and their relationship with salinity



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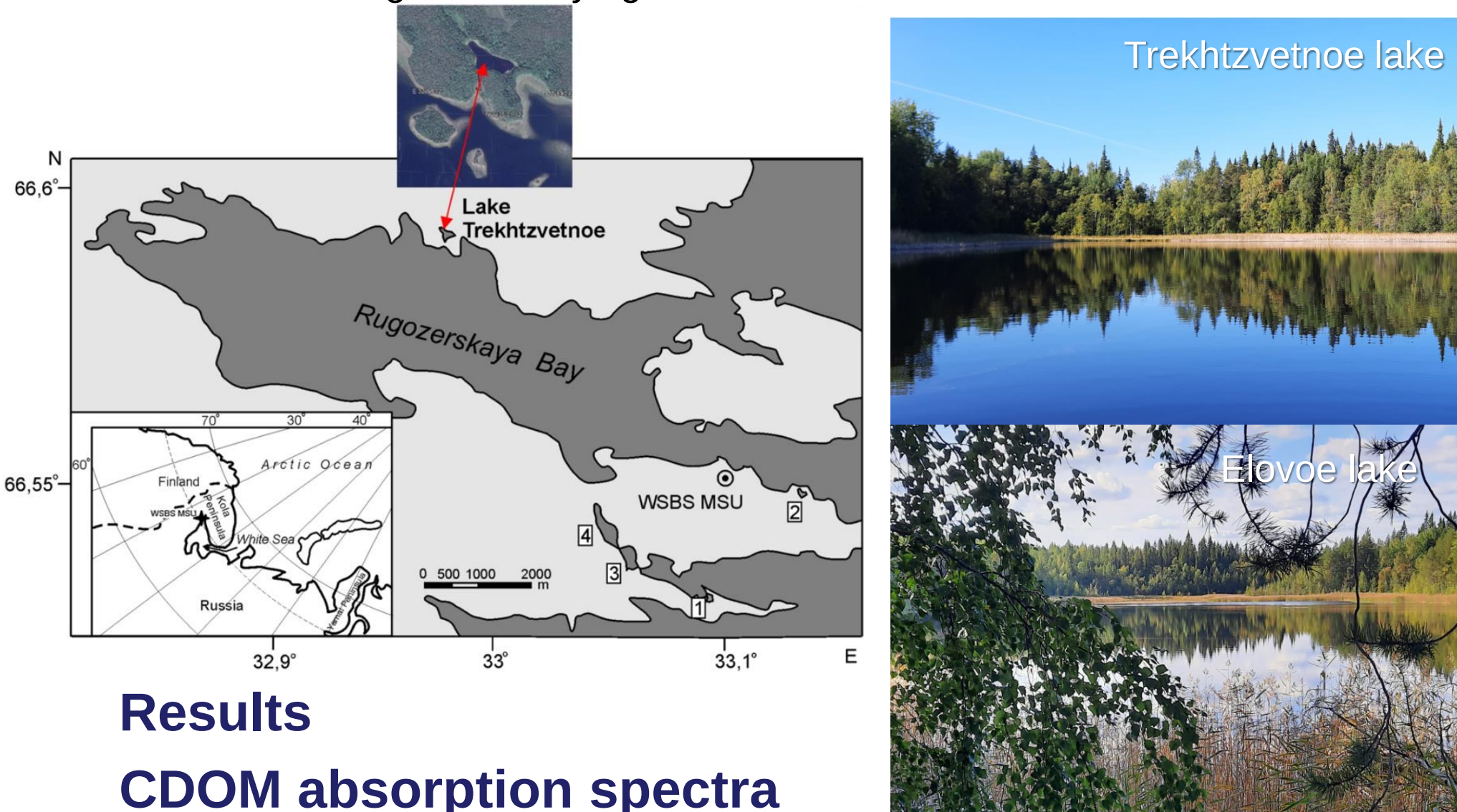
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Introduction

Chromophoric dissolved organic matter (CDOM), a colored fraction of DOM, is an important component of aquatic ecosystems, as it affects a spectral composition of sunlight passing through water and the functioning of aquatic ecosystems. From the point of view of studying composition and distribution of CDOM, the meromictic water bodies are of particular interest. The **meromictic water reservoirs** are those *with stable vertical stratification*, which occurs due to the difference in the density of water layers. The examples of such reservoirs are coastal reservoirs isolated from the White Sea, which density stratification is the result of overlapping seawater with fresh runoff. Natural CDOM effectively absorbs the UV light and emit fluorescence, therefore absorption and fluorescence spectroscopy are widely utilized for its study. The aim of this work is to compare the optical characteristics of natural CDOM in the layers with varying salinity. We present the results of spectral measurements performed on the water sampled during field campaigns in summer 2025 and 2026 in meromictic lakes Trekhtzvetnoe and Elovoe located on the coast of the Kandalaksha Gulf of the White Sea.

Materials and methods

To study CDOM, water samples were filtered through nylon filters with a pore size of 0.22 μm . Absorption spectra were recorded using Solar PB2201 spectrophotometer, fluorescence spectra were measured with Solar CM2203 luminescence spectrometer at excitation wavelength λ_{ex} varying from 250 to 500 nm.



Results

CDOM absorption spectra

The absorbances decrease along with rising wavelength, with a small "shoulder" around 260-270 nm due to the presence of phenolic groups or aromatic amino acids.

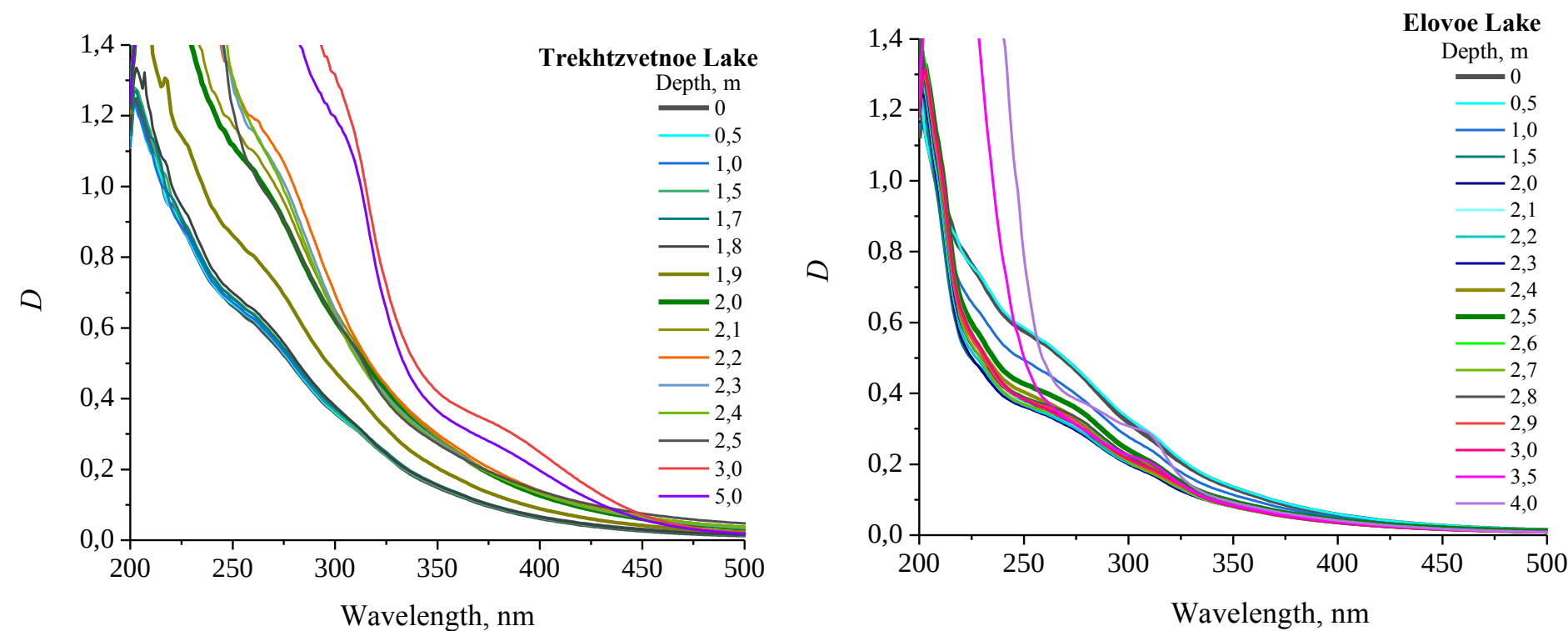


Figure 1. Absorption spectra of CDOM samples from various depths of the Lakes Trekhtzvetnoe and Elovoe.

Optical indexes and their dependences on salinity

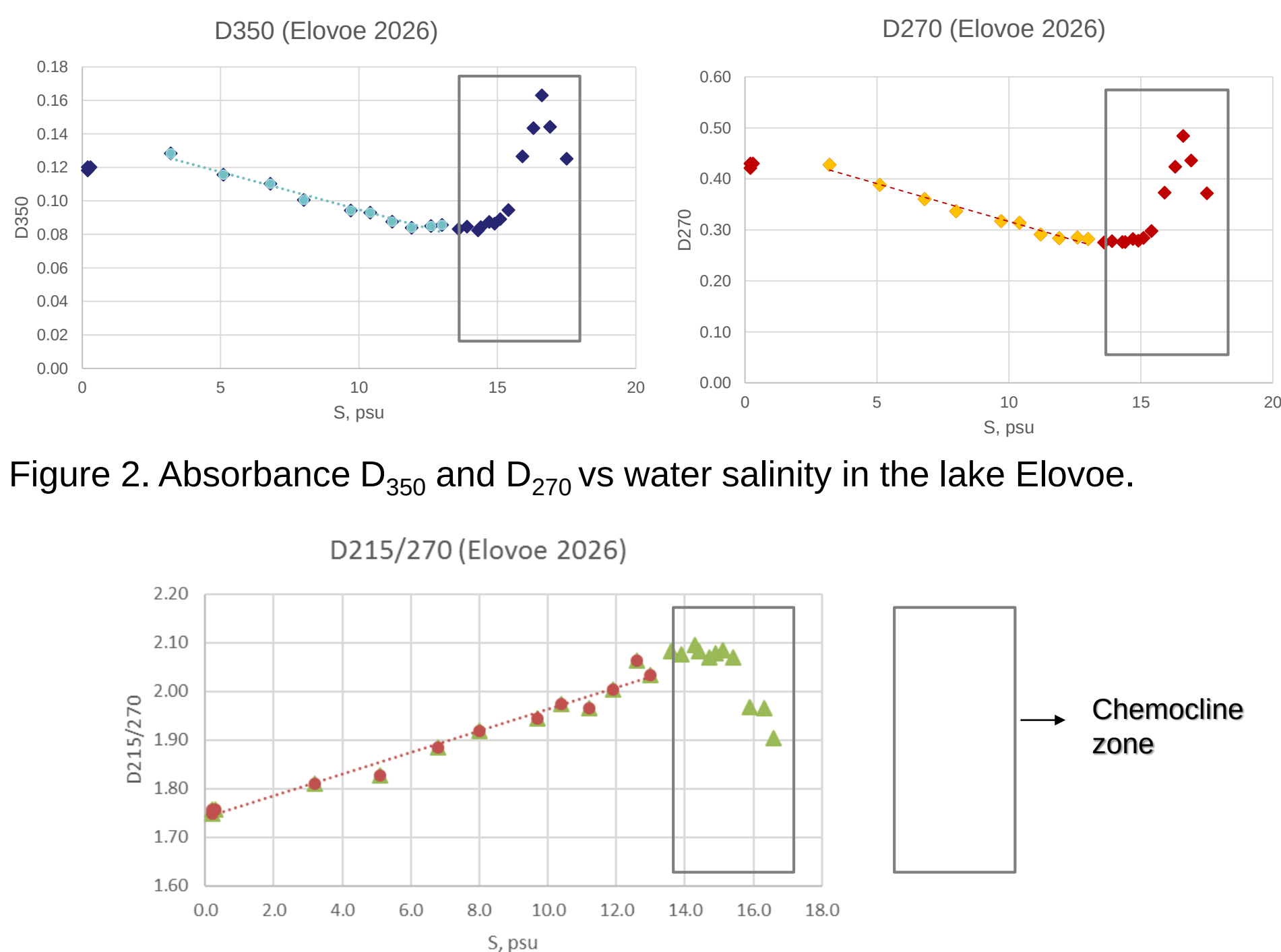


Figure 2. Absorbance D_{350} and D_{270} vs water salinity in the lake Elovoe.

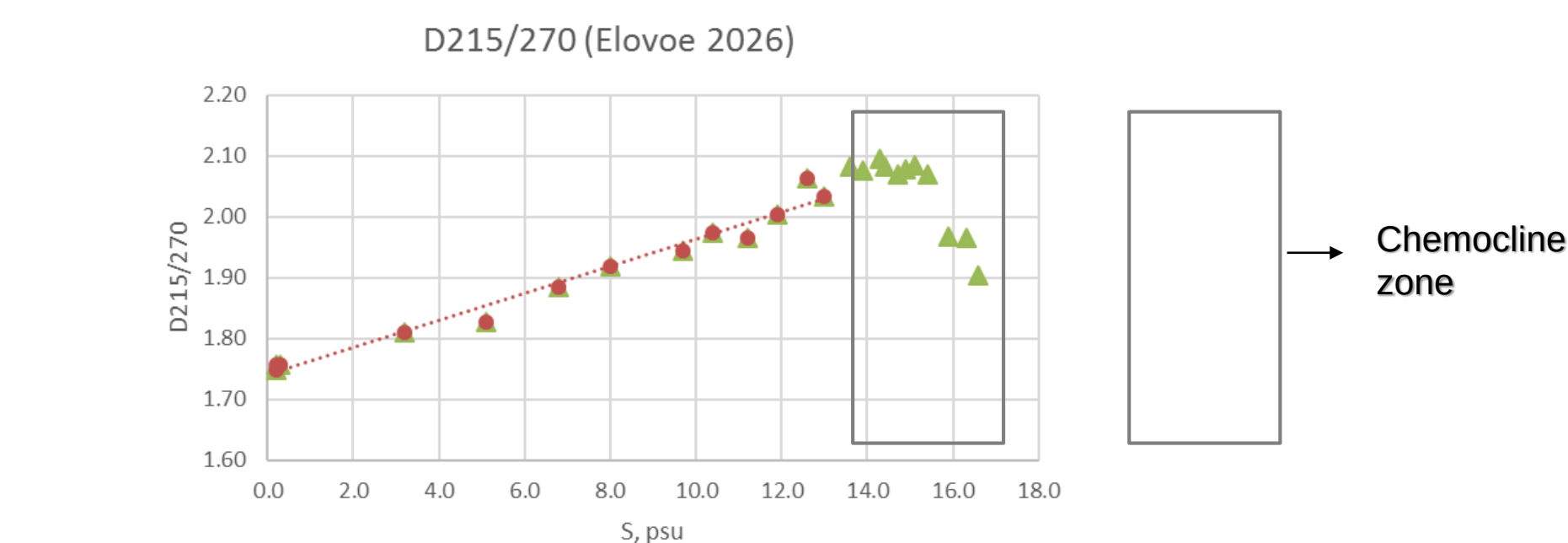


Figure 3. Absorbance ratio D_{215}/D_{270} vs water salinity in the lake Elovoe.

Fluorescence spectra

Protein-like and humic type fluorescence

When excited at 270 nm or shorter wavelengths, the CDOM fluorescence spectrum shows two overlapping bands: a "protein-like" band with a maximum at 300-350 nm and a humic type emission band with a maximum at 450-500 nm.

Emission wavelength as a function of excitation wavelength

The dependence of the wavelength of the spectrum maximum λ_{max} on the λ_{ex} is non-monotonic, the shift of the maximum of the emission towards shorter wavelengths with a change in the λ_{ex} from 280 to 310 nm corresponds to the so-called "blue shift" characteristic of natural humic substances. With a further increase in λ_{ex} , the emission maximum shifts towards longer wavelengths.

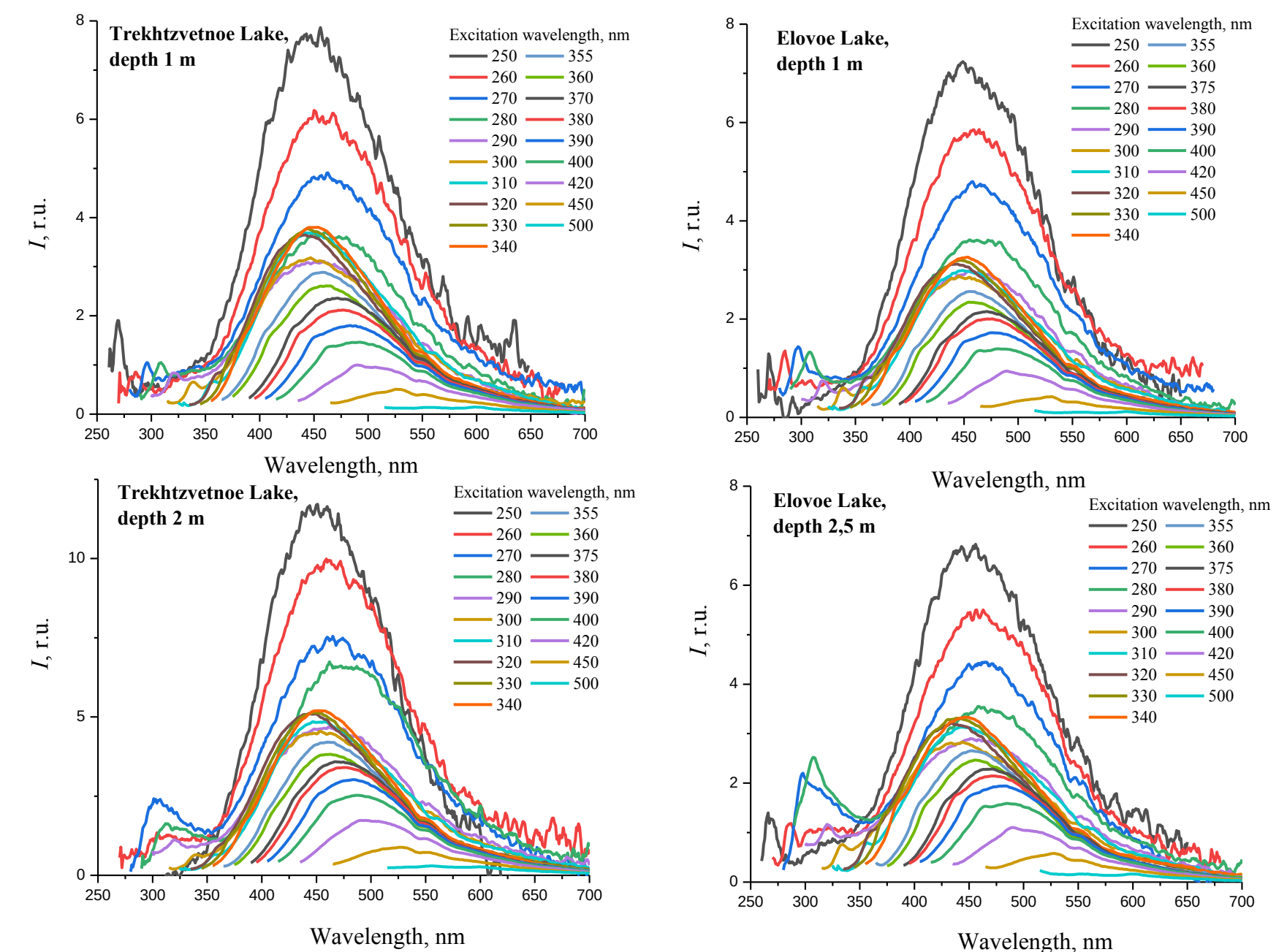


Figure 4. Fluorescence spectra of CDOM samples from various depths of the Lakes Trekhtzvetnoe and Elovoe, excited with different wavelengths.

CDOM fluorescence quantum yield

An informative optical indicator for natural CDOM is the fluorescence quantum yield. Its dependences on the λ_{ex} in different water bodies have a similar character (maxima are observed at 340 and 370–390 nm), but the absolute values of the fluorescence quantum yield vary significantly in water layers taken at different horizons, which may indicate the variability in the CDOM structural characteristics.

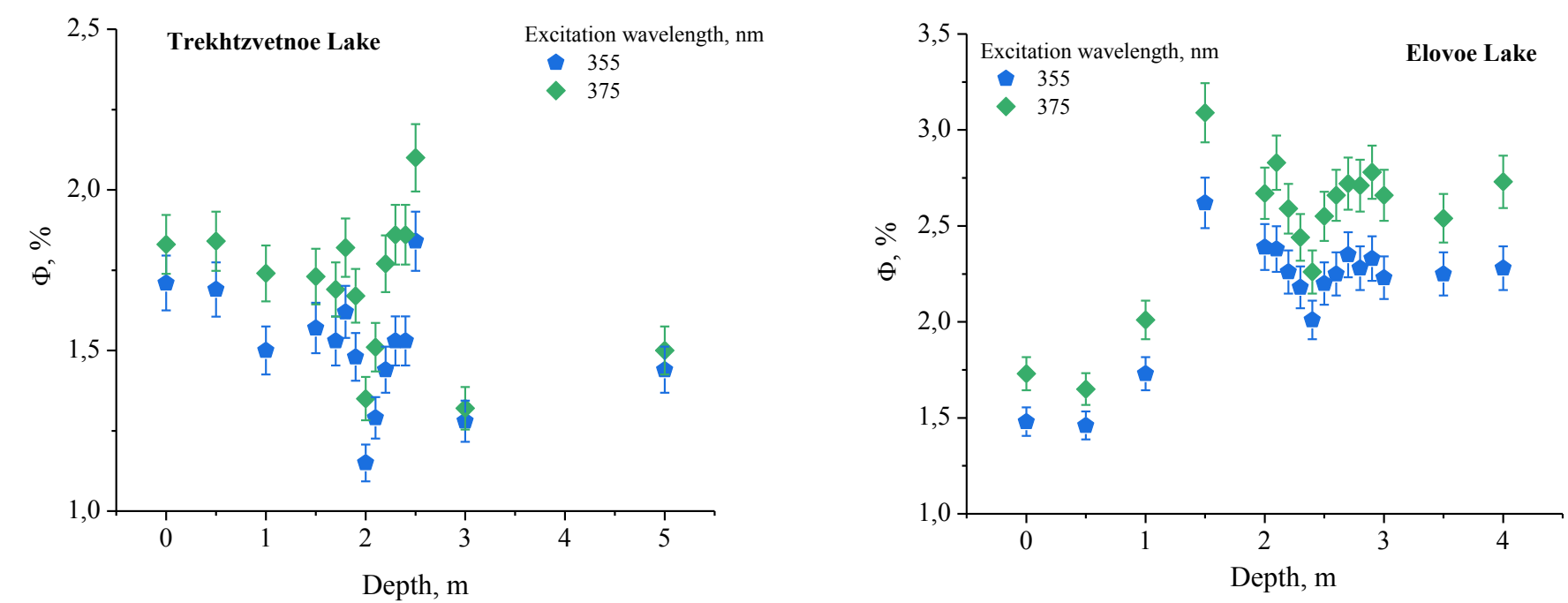


Figure 5. Fluorescence quantum yield Φ (%) for CDOM samples from various depths of the Lakes Trekhtzvetnoe and Elovoe

Conclusions

We analyzed the CDOM spectral characteristics in two meromictic lakes Elovoe and Trekhtzvetnoe, located on the coast of the Kandalaksha Bay (the White Sea). The difference in optical indices at depths with varying salinity (the surface fresh layer, the intermediate brackish aerobic layer, the chemocline and saline bottom hydrogen sulfide zone) was noticed:

- In the zone of water mixing absorbances and optical indexes were changing gradually, characterizing conservative mixing of fresh and sea water along the salinity gradient. Absorbances D_{350} and D_{270} , as well as the ratio D_{215}/D_{270} linearly correlated with salinity within aerobic layer.
- Within the chemocline zone the abnormal behavior of spectral-optical characteristics of CDOM was observed and explained by formation of autochthonous CDOM within this water layer.
- An increase in the quantum yield of CDOM fluorescence in the chemocline of the Lake Elovoe and its decrease in the Lake Trekhtzvetnoe are explained with different microbial activities under varying hydrogen sulfide concentrations.

Understanding reasons of changeability of optical properties of CDOM is of key importance when solving problems like remote sensing, research of carbon cycle and ecological monitoring of coastal waters.